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## DISCLOSURE

### CARBONIZATION APPARATUS FOR PRODUCING ACTIVATED CARBON

#### TECHNICAL FIELD

[0001]

This invention relates to a carbonization apparatus for producing activated carbon by subjecting organic waste material to be treated such as garbage, wood debris, meat-and-bone meal, waste clothes and plastic wastage to carbonization treatment such as drying, dry distillation and activation processes.

#### BACKGROUND ART

[0002]

There has been so far known a method for disposing of waste material, which is formed chiefly of one or more of garbage, waste wood and paper diaper, by carbonization of the waste material by exposure to high-temperature steam of 510 to 900°C in an oxygen-free condition. It has been seen that such a conventional waste disposal method is capable of effectively carbonizing the waste material by exposure to the high-temperature steam for a predetermined time to reduce the size or weight of the waste material to one-hundredth part of the original. (cf. Patent Reference #1)

[0003]

Further, there has been conventionally known thermal treatment equipment for producing carbide of organic waste such as brewer's grains by dry distillation. This thermal treatment equipment comprises a heat treating chamber having a waste intake port on one end side of the chamber and a product discharge port and a gas exhaust port on the other end side of the chamber, which heat treating chamber is provided with a hot-air inflow port, an stirring shaft having a number of stirring blades evenly spaced apart in the axial direction, which stirring shaft is rotatably arranged extending from the said one end side to the said other end side, so that the waste to be heat-treated is thrust toward the product discharge port with the stirring blades rotating.

[0004]

The organic waste such as brewer's grains to be treated with the aforesaid thermal treatment equipment is fed into the heat treating chamber through the waste intake port and sent toward the product discharge port while being forcibly stirred with the rotation of the stirring blades mounted on the stirring shaft. The waste fed into the heat treating chamber is thermally treated while stirred continuously during the course of moving from the waste intake port to the product discharge port by hot air introduced from a hot-air intake port formed in the heat treating chamber. By bringing the waste into even gas-solid contact with the hot air of about 650°C for example, mass transfer and heat transfer are expedited to be uniformly heat-treated, consequently to cause dry distillation (carbonization) of solids. As a result, homogeneous carbide products can be produced (cf. Patent Reference #2).

[0005]

Moreover, there has been known a carbide producing method for producing carbide from organic waste with carbonization treatment, whereby heat energy of the exhaust steam discharged after overheating the organic compound can be used as a heat source (cf. Patent Reference #3)..

[Patent Reference #1] Japanese Patent Application Publication No. 2000-313884-A1

(Pages 1-3, FIG 1)

[Patent Reference #2] Japanese Patent Application Publication No. H10-237453

(Pages 1, 2 and 9, FIG 1)

[Patent Reference #3] Japanese Patent Application Publication No. 2001-192670

(Pages 2 and 5, FIG 1)

## DISCLOSURE OF INVENTION

### PROBLEMS TO BE SOLVED BY THE INVENTION

[0006]

According to the waste disposal method disclosed in the aforementioned Patent Reference #1, the waste seems to be effectively carbonized by exposure to the high-temperature steam for a predetermined time to reduce the volume or weight of the waste to a hundredth of the initial one. However, the exhaust gas generated in the process for carbonizing the waste is cooled

with a cooling device and separated into liquid and gas parts in the conventional waste disposal method.

[0007]

The gas part thus separated is released into the atmosphere by using an exhaust fan after passing through a deodorization device filled with absorbent such as activated carbon or retrieved to be re-used as fuel for a boiler. However, such exhaust gas cannot be retrieved directly in the form of heat energy, as a result of which an enormous amount of heat energy is not reused and lost wastefully. Thus, it is disadvantageously impossible for the conventional method to produce quality carbide at low cost.

[0008]

The thermal treatment equipment of the aforesaid Patent Reference #2 is thought to enable uniform gas-solid contact with the hot air blown from a number of hot-air blowing nozzles. However, as the high-temperature steam is introduced into inside the rotating shaft, the conventional equipment is complicated in structure, posing a problem in endurance of sealing parts. Besides, the conventional equipment has further problems in that quality carbide cannot be produced because the blown hot air contains steam, which is mixed in with a large amount of impurities in the previous process, even if the hot air is blown from the nozzle near the product discharge port in the final process of treating the organic waste.

[0009]

In the carbide producing method of Patent Reference #3, useful components, which may possibly be contained in the gas or liquid content of the exhaust steam, are retrieved to be reused. To be more specific, as disclosed in the paragraph [0056] and following parts in the aforesaid Patent Reference, the exhaust steam is subjected to gas-liquid separation with a gas-liquid separation recovery device to retrieve the impurities containing even usable materials in the exhaust steam, and then, the heat energy in the exhaust steam of the hot gas separated from the impurities is used as the heat source for generating the steam.

[0010]

However, the retrieved heat energy is not very large in quantity because only the heat energy in the exhaust steam is retrieved in the conventional method. Besides, there is a disadvantageous possibility of discharging the impurities and odiferous substance contained in

the exhaust steam out of a thermal decomposition.

[0011]

The present invention was made in considering of the above problems and seeks to provide a carbonization apparatus capable of producing activated carbon at a low cost by subjecting potential heat generated by subjecting the whole of exhaust steam to burning treatment in a deodorizing furnace and retrieving the potential heat with a waste heat boiler to utilize the heat.

MEANS OF SOLVING THE PROBLEMS

[0012]

In order to solve the above problems according to the present invention, there is provided a carbonization apparatus for producing activated carbon by subjecting an organic waste material to be treated such as raw garbage, wood debris, meat-and-bone meal, waste clothes and plastic wastage to carbonization treatment including heating, drying, dry distillation and activation processes using steam, which apparatus comprises a drying carbonization furnace for drying and carbonizing the waste material with overheated steam introduced thereto and discharging spent steam which is no longer required, a high-temperature steam generator for generating, from the steam introduced therein, the overheated steam to be fed to the drying carbonization furnace, a deodorizing furnace for deodorizing impurities contained in the spent steam discharged from the drying carbonization furnace by heating the steam and discharging the steam reaching a high temperature, and a waste heat boiler for generating steam from water heated with the high-temperature steam discharged from the deodorizing furnace.

[0013]

Further, in order to solve the above problems according to the present invention, there is provided a carbonization apparatus for producing activated carbon, which comprises a carbonization furnace for carbonizing waste material to be treated with overheated steam introduced thereto and discharging spent steam which is no longer required, a drying furnace for drying the waste material with the steam introduced from the carbonization furnace and discharging the spent steam, a high-temperature steam generator for generating, from the steam introduced therein, the overheated steam to be fed to the carbonization furnace, a deodorizing

furnace for deodorizing impurities contained in the spent steam discharged from the drying furnace by heating the steam and discharging the steam reaching a high temperature, and a waste heat boiler for generating steam from water heated with the high-temperature steam discharged from the deodorizing furnace.

[0014]

Further, in order to solve the above problems according to the present invention, there is provided a carbonization apparatus for producing activated carbon, which comprises a carbonization accelerating furnace for accelerating carbonization of waste material to be treated with overheated steam introduced thereto and discharging spent steam which is no longer required, a carbonization furnace for carbonizing the waste material with overheated steam discharged from the carbonization accelerating furnace and introduced thereto and discharging the spent steam, a drying furnace for drying the waste material with the steam introduced from the carbonization furnace and discharging the spent steam, a high-temperature steam generator for generating, from the steam introduced therein, the overheated steam to be fed to the carbonization furnace, a deodorizing furnace for deodorizing impurities contained in the spent steam discharged from the drying furnace by heating the steam and discharging the steam reaching a high temperature, and a waste heat boiler for generating steam from water heated with the high-temperature steam discharged from the deodorizing furnace.

[0015]

Further, in order to solve the above problems according to the present invention, the carbonization apparatus for producing activated carbon is featured in that the drying furnace, carbonization furnace, drying carbonization furnace or carbonization accelerating furnace is provided with a cylinder shell having a waste intake port for introducing waste material to be treated, a cylinder part for stirring and moving the waste material, an exhaust port for discharging the waste material, and a steam inlet port for introducing overheated steam or spent steam tangentially from the outside of the cylinder part to the inside of the cylinder part, and rotatable stirring blades for stirring and moving the waste material in the cylinder shell.

[0016]

Further, in order to solve the above problems according to the present invention, the carbonization apparatus for producing activated carbon is featured in that the steam inlet port is

formed to introduce the overheated steam or spent steam in the same direction tangent to the inner surface of the cylinder as the rotation direction of the stirring blades. Further, in order to solve the above problems according to the present invention, the carbonization apparatus for producing activated carbon is featured in that the cylinder shell is provided with a plurality of steam inlet ports.

[0017]

Further, in order to solve the above problems according to the present invention, the carbonization apparatus for producing activated carbon is featured in that the cylinder shell is provided with a steam discharge port from which the spent steam after heating the waste material in the cylinder shell is discharged in the direction tangent to the inner surface of the cylinder part from the inside of the cylinder part to the outside of the cylinder part.

[0018]

Further, in order to solve the above problems according to the present invention, the carbonization apparatus for producing activated carbon is featured by comprising a pressure regulation means or restriction means for adjusting the overheated steam or spent steam to be fed to the drying carbonization furnace or carbonization accelerating furnace to 5 to 20(m/s).

#### EFFECT OF THE INVENTION

[0019]

Since the carbonization apparatus for producing activated carbon according to the present invention comprises the carbonization furnace for carbonizing waste material to be treated with overheated steam introduced thereto and discharging spent steam which is no longer required, the drying furnace for drying the waste material with the steam introduced from the carbonization furnace and discharging the spent steam, the high-temperature steam generator for generating, from the steam introduced therein, the overheated steam to be fed to the carbonization furnace, the deodorizing furnace for deodorizing impurities contained in the spent steam discharged from the drying furnace by heating the steam and discharging the steam reaching a high temperature, and the waste heat boiler for generating steam from water heated with the high-temperature steam discharged from the deodorizing furnace, the heat contained in the high-temperature steam discharged from the deodorizing furnace can be reused effectively.

Furthermore, since the reused heat is fed to the high-temperature steam generator, the overheated steam of high temperature can easily be generated at a low cost. Further, by reacting the overheated steam of high temperature, which is generated by the high-temperature steam generator with the waste material to be treated, activated carbon of high quality can be produced at a low cost. Moreover, since the carbonization apparatus for producing the activated carbon is provided with the deodorizing furnace, the apparatus according to the invention enables discharge of gas or steam having a low content of dioxin to meet environmental standards.

[0020]

Further, since the carbonization apparatus for producing activated carbon according to the invention has the drying furnace, carbonization furnace, drying carbonization furnace or carbonization accelerating furnace provided with the cylinder shell having a waste intake port for introducing waste material to be treated, the cylinder part for stirring and moving the waste material, the exhaust port for discharging the waste material, and the steam inlet port for introducing overheated steam or spent steam tangentially from the outside of the cylinder part to the inside of the cylinder part, and the rotatable stirring blades for stirring and moving the waste material in the cylinder shell, the overheated steam flows in a swirl to easily come in contact with the waste material to be treated, consequently to expose the waste material to the overheated steam of high temperature for a long time. As a result, drying, carbonization, dry distillation and activation processes can be expedited to enable production of activated carbon of high quality.

[0021]

Since the cylinder shell having one or more steam inlet ports in the carbonization apparatus for producing activated carbon according to the invention is formed to introduce the overheated steam or spent steam in the same direction tangent to the inner surface of the cylinder as the rotation direction of the stirring blades, the waste material can be exposed to the overheated steam of high temperature for a long time. Thus, drying, carbonization, dry distillation and activation processes can be expedited to enable production of activated carbon of high quality. Also, the waste material can be exposed to the high temperature overheated steam flowing in a whirl for a long time by the provision of the multiple steam inlet ports formed in the cylinder

shell,

[0022]

Further, since the cylinder shell of the carbonization apparatus for producing activated carbon is provided with the steam discharge port from which the spent steam after heating the waste material in the cylinder shell is discharged in the direction tangent to the inner surface of the cylinder part from the inside of the cylinder part to the outside of the cylinder part, the overheated steam flows in a swirl to easily come in contact with the waste material to be treated. As a result, drying, carbonization, dry distillation and activation processes can be expedited to enable production of activated carbon of high quality.

[0023]

Further, since the carbonization apparatus for producing activated carbon of the invention according to the invention has the pressure regulation means or restriction means for adjusting the overheated steam or spent steam to be fed to the drying carbonization furnace or carbonization accelerating furnace to 5 to 20(m/s), the steam moves in a whirl within the reaction furnace, while maintaining a large relative velocity to the waste material, consequently to enhance heat transfer to the waste material so as to bring the temperature of the waste material close to the temperature of the steam. As a result, drying, carbonization, dry distillation and activation processes can be expedited to enable production of activated carbon of high quality.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0024]

FIG 1: Block diagram showing entirely a carbonization apparatus for producing activated carbon according to the invention.

FIG 2: View showing steam inlet ports formed in a carbonization furnace for introducing overheated steam.

#### DESIGNATION OF COMPONENT NUMBERS

[0025]

- 10 Carbonization apparatus for producing activated carbon
- 20 Waste feeding means

- 22 Hopper
- 24 Conveyer
- 26 Feeder
- 30 Drying furnace
- 31 Cylinder shell
- 32 Waste intake port
- 33 Cylinder part
- 34 Stirring blades
- 35 Discharge port
- 36 Steam inlet port
- 37 Steam discharge port
- 40 Carbonization furnace
- 41 Cylinder shell
- 42 Waste intake port
- 43 Cylinder part
- 44 Stirring blades
- 45 Discharge port
- 46, 46A, 46B and 46C Steam inlet ports
- 47 Steam discharge port
- 50 Discharge device
- 52 Cooling jacket
- 54 Product tank
- 56 Screw conveyer
- 60 High-temperature steam generator
- 62 Air blower
- 64 LPG bottle
- 66 Governor
- 68 Burner
- 70 Deodorizing furnace
- 72 Deodorizing furnace blower

- 74 Kerosene tank
- 76 Kerosene lamp
- 80 Waste heat boiler
- 90 water feeding device
- 92 Water softener
- 94 Soft water tank
- 95 water feeding pump
- 96 Filter device
- 98 Exhaust cylinder

#### BEST MODE FOR CARRYING OUT THE INVENTION

[0026]

The carbonization apparatus for producing activated carbon according to the invention will be described hereinafter with reference to the accompanying drawings.

#### EMBODIMENT 1

[0027]

FIG 1 shows a block diagram of the entire carbonization apparatus for producing activated carbon according to the invention. As shown in this drawing, the carbonization apparatus 10 comprises a waste feeding means 20 for storing organic waste material to be treated such as garbage, wood debris, meat-and-bone meal, waste clothes and plastic wastage and feeding the waste material to an appropriate drying furnace 30 for drying the waste material with steam discharged from a carbonization furnace 40 in which the waste material dried by the drying furnace 30 is carbonized with overheated steam fed from a high-temperature steam generator 60 to make activated carbon and discharged the activated carbon in company with spent steam after used in the carbonization furnace, and a discharge device 50 for cooling and storing the activated carbon resulted from the carbonization in the carbonization furnace.

[0028]

The carbonization apparatus 10 further comprises a high-temperature steam generator 60 for generating high-temperature overheated steam with steam fed from a waste heat boiler 80 and feeding the generated steam the carbonization furnace 40, a deodorizing furnace 70 for

heating impurities contained the spent steam discharged from the drying furnace 30 to deodorize the spent steam, consequently to discharge high-temperature gas, a waste heat boiler 80 for heating water with the high-temperature gas discharged from the deodorizing furnace 70 to generate steam to be fed to the high-temperature steam generator 60, a water feeding device 90 for feeding water to the waste heat boiler 80, a filter device 90 such as a cyclone collector for collecting particulates or moisture contained in exhaust gas discharged from the deodorizing furnace 70 and subjected to heat exchanged by the waste heat boiler 80, and an exhaust cylinder 98 through which the exhaust gas from the filter device is discharged into atmosphere.

[0029]

The waste feeding means 20 comprises a hopper 22 for storing organic waste material to be treated such as garbage, wood debris, meat-and-bone meal, waste clothes and plastic wastage, a conveyer 24 for feeding the waste material stored in the hopper 22 to a feeder 26 for quantitatively feeding the waste material to the drying furnace 30.

[0030]

The drying furnace 30 has a cylinder shell 31 comprising a waste intake port 32 for introducing the waste material quantitatively fed from the feeder 26, a cylinder part 33 for drying and dry-distilling the waste material in the cylinder shell while stirring and moving the waste material, one or more stirring blades 34 such as a rotatable propeller feeder for stirring and moving the waste material while drying and dry-distilling the waste material in the cylinder shell 31, a discharge port 35 for discharging the dried and dry-distilled waste material therethrough, a steam inlet port 36 for introducing steam discharged out of the carbonization furnace 40 from the outside of the cylinder part 33 in the same direction tangent to the inner surface of the cylinder (tangential direction) as the rotation direction of the stirring blades 34, and a steam discharge port 37 for discharging the spent steam after heating the waste material in the cylinder shell 31 from the inside of the cylinder part 33 in the direction tangent to the inner surface of the cylinder part 33 (tangential direction) to the outside of the cylinder part.

[0031]

The cylinder shell 41 of the carbonization furnace 40 comprises a waste intake port 42 for dried waste material discharged from the drying furnace 30 through the discharge port 35, a cylinder part 43 for drying, dry-distilling, carbonizing and activating the waste material while

stirring and moving the waste material, one or more stirring blades 44 such as a rotatable screw-type conveyer or propeller feeder for drying, dry-distilling, carbonizing and activating the waste material under low-oxygen conditions in the cylinder shell 41, a discharge port 45 for discharging the dry-distilled, carbonized and activated waste material, a steam inlet port for introducing, from the outside of the cylinder 43, overheated steam of 900 to 1200°C fed from the high-temperature steam generator 60 in the same direction tangent to the inner surface of the cylinder (tangential direction) as the rotation direction of the stirring blades 44, and a steam discharge port 47 for discharging the spent steam after heating the waste material in the cylinder shell 41 from the inside of the cylinder part 43 in the direction tangent to the inner surface of the cylinder part 43 (tangential direction) to the outside of the cylinder part.

[0032]

It is desirable to flow the spent steam or overheated steam to be fed to the drying furnace 30, carbonization furnace 40, drying carbonization furnace or carbonization accelerating furnace at a rate of speed in excess of 5 m/s in order for enhancing heat transfer to the waste material. However, when the flow rate of the steam is over 20 m/s, a problem such as erosion of parts used within the drying furnace 30 may possibly occur. Thus, the flow rate of the steam should be determined suitably. The flow rate of the overheated stream is controlled by regulating a pressure regulation mechanism or restriction means to befittingly determine the volume of burning air, which is fed to the high-temperature steam generator 60, the quantity of LPG gas to be applied, and the aperture diameter of the steam inlet ports 36 and 46.

[0033]

FIG 2 is a view showing the steam inlet ports formed in the carbonization furnace for introducing overheated steam.

The apparatus shown in FIG 1 has one steam inlet port 46 in the carbonization furnace 40, but a plurality of steam inlet ports 46, 46A, 46B and 46C may be formed in the carbonization furnace 40 as illustrated in FIG 2. The steam inlet ports 46, 46A, 46B and 46C serve to introduce the overheated steam discharged from the high-temperature steam generator 60 in the same direction tangent to the inner surface of the cylinder part 43 (tangential direction) as the rotation direction of the stirring blades 44.

[0034]

In the process of carbonization for producing active carbon, it is important to uniformly heat the waste material to be treated at a high temperature. The desired drying and carbonation of the waste material may be somewhat attained even by introducing the overheated steam into the carbonization furnace 40 and drying furnace 30 through one steam inlet port 36 or 46 as shown in FIG 1. However, the stirring blades 34 and 44 within the cylinder shells 31 and 41 with the waste material to be treated prevent the overheated steam to flow, consequently to possibly weaken swirling flow of the steam.

[0035]

Hence, by forming the multiple steam inlet ports 46A, 46B and 46C in the middle portion of the cylinder shell 41, the overheated steam can flow in an intrinsic strong vortex flowing state. However, if the steam inlet ports are more than needs, the vortex flowing of the overheated steam may be weakened due to weakening of the overheated steam current introduced from each steam inlet port.

[0036]

As in the case of the carbonization furnace 40, multiple steam inlet ports may be formed in the drying furnace 30, drying carbonization furnace or carbonization accelerating furnace. Furthermore, each steam inlet port may be regulated in aperture diameter by means of a pressure regulation mechanism or restriction means to control the flow rate and flow volume of the overheated steam introduced thereto.

[0037]

The discharge device 50 is provided with a cooling jacket 52 for cooling the high-temperature activated carbon carbonized and activated in the carbonization furnace 40 by using water, and a screw conveyer 56 with a water-cooling jacket for forwarding the activated carbon thus obtained to a product tank 54 while cooling the activated carbon.

[0038]

The high-temperature steam generator 60 serves to generate the overheated steam by introducing the steam from the waste heat boiler 80 into the space burned with LPG or the like by using a burner. The overheated steam thus generated by the high-temperature steam generator 60 is fed to the carbonization furnace 40 to produce the activated carbon by

dry-distilling, carbonizing and activating the waste material.

[0039]

The deodorizing furnace 70 has a function of burning the impurities contained in the spent steam, such as ammonia, mercaptan, hydrogen sulfide, methyl sulfide, methyl disulfide, trimethylamine, acetaldehyde and styrene with the spent steam, which is discharged from the carbonization furnace 40 and emitted into the atmosphere burned by using an oil burner, consequently to deodorize and discharge high-temperature exhaust gas.

[0040]

The waste heat boiler 80 serves to generate water vapor (dry steam) by heating water in a multi-stepwise manner with exhaust gas of high temperature discharged from the deodorization furnace 70. Then, the water vapor is fed to the high-temperature steam generator 60.

[0041]

The filter device 96 serves to collect particulates (solid contents) or moisture contained in the exhaust gas discharged from the deodorizing furnace 70 and subjected to heat exchanged by the waste heat boiler 80 by using a cyclone collector and eliminate smoke from the exhaust gas. Finally, the exhaust gas is cleaned and then discharged into the atmosphere through an exhaust cylinder 98.

## EMBODIMENT 2

[0042]

In the foregoing embodiment, the organic waste material is subjected to carbonization treatment such as drying, dry distillation and activation processes by using two types of reaction furnaces, i.e. the drying furnace 30 (first reaction furnace) and the carbonization furnace 40 (second reaction furnace), as described above. However, the apparatus according to the present invention should not be understood as being characterized by the aforesaid two types of reaction furnaces by which the carbonization treatment is performed.

[0043]

That is, the intended effect of the invention can be fulfilled by, for instance, generating the overheated steam of high temperature by using the overheated steam absorbing heat from the exhaust gas of high temperature discharged from the deodorizing furnace 70, drying and

carbonizing the waste material by introducing the overheated steam of high temperature into the drying carbonization furnace (first reaction furnace), and finally discharging spent steam, which is no longer required.

[0044]

The carbonization apparatus for producing activated carbon according to the invention may comprise a carbonization accelerating furnace (third reaction furnace) for expediting carbonization of the waste material with the overheated steam while discharging the spent steam which is no longer required, a carbonization furnace (second reaction furnace) for carbonizing the waste material with the steam discharged from the carbonization accelerating furnace while discharging the spent steam, a drying furnace (first reaction furnace) for drying the waste material with the steam discharged from the carbonization furnace while discharging the spent steam, a high-temperature steam generator for generating, from vapor, high-temperature overheated steam to be fed to the carbonization furnace, a deodorizing furnace for deodorizing impurities contained in the spent steam discharged from the drying furnace by heating the steam and discharging the steam reaching a high temperature, and a waste heat boiler for generating steam from water heated with the high-temperature steam discharged from the deodorizing furnace, wherein the multiple reaction furnaces are operated in a cascade manner to carbonize the waste material. Thus, the carbonization apparatus having this structure can accomplish the object of the present invention.

[0045]

An activated carbon producing method using the carbonization apparatus for producing activated carbon 10 of the invention will be described hereinafter.

First, the deodorizing furnace blower 72 is operated to feed burning air to the deodorizing furnace 70. Next, burning is carried out in the deodorizing furnace 70 while feeding kerosene from a kerosene tank 74 to the deodorizing furnace by using a kerosene pump 76, while emitting exhaust gas of 800 to 1200°C. The exhaust gas of high temperature is fed to the waste heat boiler 80.

[0046]

When rising the temperature of the waste heat boiler 80, soft water prepared by a water softener and stored in a soft water tank 94 of a water feeding device 90 is forcibly supplied to

the waste heat boiler 80 by using the water feeding pump 95. The soft water thus supplied is heated at the subsequent stage of the waste heat boiler 80. Then, the overheated steam of 150 to 300°C, which is fed to the preceding stage of the waste heat boiler 80, is sent to the high-temperature steam generator 60.

[0047]

The burning air is supplied to the high-temperature steam generator 60 by operating an air blower 62. Then, the steam is heated by burning LPG given from an LPG bottle 64 through a governor 66, so that the steam of 150 to 300°C fed from the waste heat boiler 80 is further heated to generate and feed overheated steam of 700 to 1200°C (preferably, 900 to 1100°C) to the carbonization furnace 40.

[0048]

The organic waste material such as garbage, wood debris, meat-and-bone meal, waste clothes and plastic wastage bane of activated carbon is placed beforehand in a hopper 22. The waste material in the hopper 22 is sent to a feeder 26 through a conveyer 24 in the waste feeding means 20. The feeder 26 has a function of quantifying the waste material to a prescribed amount while supplying the waste material to the drying furnace 30.

[0049]

The waste material to be treated is supplied into the cylinder shell 31 through the waste intake port 32 formed in the cylinder shell 31 of the drying furnace 30. The stirring blades 34 rotate to progressively move the waste material toward the discharge port 35 while stirring the waste material in the cylinder part 33 of the cylinder shell 31.

[0050]

The spent steam of 700 to 1000°C, which is discharged from the carbonization furnace 40, is introduced from the outside of the cylinder part 33 through the aforesaid one or more steam inlet ports 36 in the same direction tangent to the inner surface of the cylinder (tangential direction) as the rotation direction of the stirring blades 34. Thus, the steam is well mingled with the waste material stirred and advancing with the stirring blades 34, thus to cause thermolysis or hydrolysis.

[0051]

The waste material moves with the overheated steam toward the steam discharge port 37

in the cylinder part 33 while being subjected to drying, dry distillation and activation and then is discharged from the inside of the cylinder part 33 to the outside thereof in the direction tangent to the inner surface of the cylinder part 33 (tangential direction). Since the steam discharge port 37 is provided so that the spent steam is discharged in the direction tangent to the inner surface of the cylinder part 33, heat transfer between the steam and the waste material is expedited while maintaining the rotational flow of the steam within the cylinder part 33 and keeping the rotational flow of the steam relative to the waste material at high speed.

[0052]

There has conventionally been a mechanism for injecting the steam toward waste material to be treated in a drying furnace through multiple pores formed by thin pore nozzles. However, the mechanism with the multiple pores for injecting the steam has problems as follows:

[0053]

Since a stirring machine for stirring and feeding cake occupies the inner space in a common reaction furnace, it has been disadvantageously difficult for the conventional mechanism to set the pore nozzles for injecting the steam. Therefore, there has been known a complicated structure in which a steam passage is formed in a shaft of the stirring machine so as to emit the steam toward the waste material, thus expediting reaction of the waste material, as stated above.

[0054]

When the steam flows in parallel with the central axis of a cylindrical reactor, the steam passes through the inside of the reactor without any obstruction, consequently preventing effective heat transfer and reaction relative to the waste material.

[0055]

In the apparatus of the invention, the steam is introduced from the outside of the cylinder parts 33 and 43 at a flow rate of 5 to 20 m/s in the same direction tangent to the inner surface of the cylinder as the rotation direction of the stirring blades 34 and 44, so that the steam can flow in a strong vortex flowing state. The steam is ejected from the side surface near the product discharge ports 35 and 45 toward the waste material in the circumferentially tangential direction at a flow rate of 5 to 20 m/s, and then, discharged from the steam discharge ports 37 and 47 formed near the inlet ports of the waste intake ports 32 and 42 in the same circumferential

direction tangent to the inner surface of the cylinder as the rotation direction of the stirring blades 34 and 44.

[0056]

According to this mechanism, the steam moves in a whirl within the reaction furnace, while maintaining a large relative velocity to the waste material, consequently to enhance heat transfer to the waste material so as to bring the temperature of the waste material close to the temperature of the steam, so that drying, carbonization, dry distillation and activation processes can be expedited.

Meanwhile, the waste material dried by the drying furnace 30 is discharged from the discharge port 35 and sent to the carbonization furnace 40 in the subsequent treating process.

[0057]

The waste material sent out from the drying furnace 30 is fed into the cylinder shell 41 through the waste intake port 42 formed in the cylinder shell 41 of the drying furnace 40. The rotation of the stirring blades 44 within the cylinder shell 41 causes the waste material to progressively move toward the discharge port 45 while stirring the waste material.

[0058]

The overheated steam is introduced from the high-temperature steam generator 60 through one or more steam inlet ports 46, 46A,... in the same direction tangent to the inner surface of the cylinder (tangential direction) as the rotation direction of the stirring blades 44, so that the overheated steam can flow in a strong vortex flowing state. Therefore, the overheated steam is well mingled with the waste material stirred and advancing with the stirring blades 44, and then, sent toward the steam discharge port 47 of the cylinder part 43 while subjecting the waste material to drying, dry distillation and activation. Subsequently, the spent steam is discharged from the inside of the cylinder part 34 to the outside of the cylinder part in the direction tangent to the inner surface of the cylinder part 43 (tangential direction).

[0059]

Since the steam discharge port 47 is formed so that the spent steam can be discharged in the tangential direction to the inner surface of the cylindrical part 43, the steam is well mingled with the waste material stirred and advancing with the stirring blades 34, thus to expedite thermolysis or hydrolysis. In order to produce activated carbon of high quality, it is desirable

to keep the waste material to be treated at a temperature over 800°C. Further, to achieve this effect, it is ideal to expose the waste material to the overheated steam of high temperature containing little oxygen to be activated.

[0060]

By reacting the waste material to be treated with the overheated steam of a high temperature of 700 to 1200°C in the carbonization furnace 40, it is possible to produce the activated carbon of high quality in a short time. Since the steam to be supplied to the high-temperature steam generator is further heated with heat retrieved from the exhaust gas of high temperature exhausted after the deodorization process in the apparatus of the invention, the cost of producing the activated carbon can be decreased.

The activated carbon produced by carbonizing and activating the waste material is sent out to the discharge device 50 through the discharge port 45.

[0061]

Since it is desirable to place the activated carbon of high temperature discharged from the carbonization furnace 40 in an oxygen atmosphere, the active carbon may be cooled with a cooling jacket 52 of the discharge device 50. Additionally, the activated carbon may be conveyed to the product tank 54 by a screw conveyer 56 with a cooling jacket while being cooled with the cooling jacket.

[0062]

Meanwhile, the spent steam which is discharged from the drying furnace 30 and no longer required has a temperature of 340 to 740°C. Since the spent steam contains harmful components such as nitrogen compound and fumes, it is necessary to complete burning of impurities contained in the exhaust gas at a high temperature in the deodorizing furnace 70. Even if the impurities is burned at a temperature below 800°C, dioxins are yielded. Therefore, the spent steam containing the aforesaid harmful components should be heated at a temperature of 800 to 1200°C in the deodorizing furnace 70 to be decomposed and discharged.

[0063]

Although the spent steam from the deodorizing furnace 70 has conventionally been directly released into the atmosphere through the exhaust cylinder 98 of the filter device 96, the exhaust gas in the present invention is effectively reused for collecting the heat of the exhaust

gas in generating the steam in the waste heat boiler 80, consequently to save energy required for producing the activated carbon of high quality. Because the exhaust gas obtained after heat exchange in the waste heat boiler 80 is 100 to 400°C, considerable amount of heat can be retrieved.

[0064]

In order for generating the steam of a high temperature over 1000°C by using a common boiler or superheater, a heat exchanger tube or pipe made of high-temperature superalloy is required, thus causing disadvantages of complicated structure, less durability and rising costs of making manufacturing equipment for the activated carbon producing apparatus. To surmount the disadvantages according to the invention, the overheated steam of 150 to 300°C obtained by heat exchange of the exhaust gas of high temperature discharged from the deodorizing furnace 70 is treated by the high temperature steam generator 60 composed of high-temperature ceramic components, consequently to generate the overheated steam of high temperature, as the result of which the cost of manufacturing the activated carbon producing apparatus and the running cost of working the apparatus can be lowered.

[0065]

The exhaust gas yielded after performing heat exchange with the waste heat boiler 80 is supplied to the filter device 96 having a cyclone collector to collect particulates or moisture contained in the exhaust gas, and then, released to the atmosphere via the exhaust cylinder 98.

#### INDUSTRIAL APPLICABILITY

[0066]

According to the carbonization apparatus for producing activated carbon of the present invention, the overheated steam of high temperature can easily be generated by reusing the heat contained in the exhaust gas discharged from the deodorizing furnace. By reacting the overheated steam of high temperature with the waste material to be treated, the activated carbon of high quality can be produced at a low cost.

[0067]

Furthermore, according to the carbonization apparatus for producing activated carbon of the invention, which comprises the drying furnace, carbonization furnace, drying carbonization

furnace or carbonization accelerating furnace with the featured cylinder shell, the overheated steam flows in a swirl at a high speed to easily come in contact with the waste material to be treated, consequently to enhance heat transfer to the waste material so as to allow the temperature of the waste material to reach a high temperature. As a result, drying, carbonization, dry distillation and activation processes can be expedited to enable production of activated carbon of high quality.

[0068]

Further, since the drying furnace, carbonization furnace, drying carbonization furnace or carbonization accelerating furnace of the carbonization apparatus for producing activated carbon according to the present invention has the featured cylinder shell with one or more steam inlet ports so that the overheated steam or spent steam is introduced in the same direction tangent to the inner surface of the cylinder as the rotation direction of the stirring blades, the steam can be brought into contact with the waste material for a ample time at a sufficient relative speed. As a result, drying, carbonization, dry distillation and activation processes can be expedited to enable production of activated carbon of high quality.

[0069]

Further, since the cylinder shell of the carbonization apparatus for producing activated carbon according to the present invention is provided with the steam discharge port for discharging the spent steam in the direction tangent to the inner surface of the cylinder part from the inside of the cylinder part to the outside of the cylinder part, the steam can be brought into contact with the waste material at a high relative speed, while flowing in a whirl, thus to expedite heat transfer to the waste material. As a result, the waste material can be exposed to the overheated steam of high temperature for a long time, so that drying, carbonization, dry distillation and activation processes can be expedited to enable production of activated carbon of high quality.

[0070]

Further, since the drying furnace, carbonization furnace, drying carbonization furnace or carbonization accelerating furnace of the carbonization apparatus for producing activated carbon according to the present invention is arranged so as to feed the overheated steam or spent steam at a flow rate of 5 to 20 m/s, the steam moves in a whirl within the reaction furnace,

while maintaining a large relative velocity to the waste material, consequently to enhance heat transfer to the waste material so as to bring the temperature of the waste material close to the temperature of the steam. As a result, drying, carbonization, dry distillation and activation processes can be expedited to enable production of activated carbon of high quality.